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The Role of Imaging in Acute Appendicitis among Children from a Community Hospital

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Abstract

Background: Acute appendicitis is one of the most common surgical emergencies with a lifetime prevalence of approximately 1 in 7. Early diagnosis and prompt surgical intervention is the key for successful management of acute appendicitis and avoidance of complications. With increased availability of advanced imaging, computed tomography (CT) has become the primary modality for evaluating patients with abdominal pain in many institutions across the United States. The incidence of appendicitis and it propensity to occur in younger patients strongly argue for judicious use of CT.

Objective: Our goal is to reduce the use of CT scans and potential radiation risk in the diagnosis of acute appendicitis.

Method: We conducted a retrospective chart review of hospital data of patients who presented to the Emergency Department with abdominal 2006 to 2010. Statistical analysis was done using STATA 11.0 statistical software.

Results: There were 175 patients who met the inclusion criteria for the study. There were no statistically significant differences in baseline characteristics between patients with Alvarado ≥ 7 and those with Alvarado<7. Patients with Alvarado ≥ 7 made up 50.9% of our study population. Abdominal CT scan was ordered in 63.4% of the patients; 44.8% with Alvarado ≥ 7. There was no significant difference in proportion with CT scan order between those who had Alvarado score ≥ 7 and those with Alvarado score<7 (p-value 0.19) after adjusting for age, gender and BMI.

Conclusion: We found no significant difference between CT scan order and Alvarado score. There was no significant difference between Alvarado score and gender, race/ethnicity or BMI. Despite the wealth of information regarding the role of clinical skills in reducing the need for imaging in diagnoses of acute appendicitis, our study showed no difference in CT ordering based on clinical presentation.

Keywords: CT scan; Alvarado score; Pediatrics

Abbreviations

ED: Emergency Department; WBC: White Cell Count; CT: Computer Tomography; RLQ: Right Lower Quadrant; BMI: Body Mass Index; Temp: Temperature; ≥: Greater than or equal to; <: Less than

Background

Acute appendicitis is one of the most common surgical emergencies with a lifetime prevalence of approximately 1 in 7 [1]. In the United States the annual age adjusted rate of acute appendicitis is 9.38 per 10,000 with a lifetime risk of 8.6% for males and 6.7% for female [2,3]. Early diagnosis and prompt surgical intervention is the key for successful management of acute appendicitis. Early diagnosis also helps reduce the incidence of complications such as perforation and peritonitis [4].

With increased availability of advanced imaging, computed tomography (CT) has become the primary modality for evaluating patients with abdominal pain in many institutions across the United States. Increased reliance on CT has not come without risk. Pediatric patients are more radiosensitive. The incidence of appendicitis and it propensity to occur in younger patients strongly argue for judicious use of CT [5,6].

Various scoring systems have been developed to aid diagnosis of acute appendicitis. The most notable of which is the Alvarado scoring system first described in 1986 [7]. Alvarado retrospectively reviewed a group of 305 hospitalized patients with abdominal pain suggestive of appendicitis, and identified eight factors predictive of acute appendicitis. Based on the weight of their association, each factor was given a score that, when summed makes up the Alvarado Score.

Objectives

Our goal is to reduce the use of CT scans and potential radiation risk in the diagnosis of acute appendicitis [6]. Thus we aim to implement a validated pediatric clinical score in our Emergency Department (ED) and develop specific criteria for requesting imaging studies to diagnose acute appendicitis, to improve patient safety and

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decrease incidence of perforation by reducing Emergency Department wait times.

Methods

Data set

We conducted a retrospective chart review of hospital data of patients who presented to the Emergency Department with abdominal pain as well as signs and symptoms suggestive of acute appendicitis based on the Alvarado scoring system. Patient records were abstracted from both the electronic medical records as well as patient folders kept in the records department. Charts were abstracted over 5 year period from 2006 to 2010. Children between the ages of 2 and 18 years were selected. Parameters abstracted from the records included age, sex, ethnicity, height, weight, CT scan order, and Emergency Department wait time; time to CT scan and time to surgery. The intraoperative diagnoses as well as the final pathology report were also extracted from the records.

Exclusion criteria were patients who had incomplete records. There were 10 patients with missing date on race/ethnicity, 11 patients with missing data on operative report, 13 patients with missing date on pathology report and two patients with missing data on height.

Covariates analyzed were age, sex, and Body Mass Index (BMI), ethnicity.

Measures

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and converted to age and gender specific percentiles using the 2010 WHO growth charts. Children less than 2 years of age were excluded because BMI is not a validated measure below this age. Race/Ethnicity was subdivided into 5 categories: Hispanic, Black/African American, White, Asian, Other.

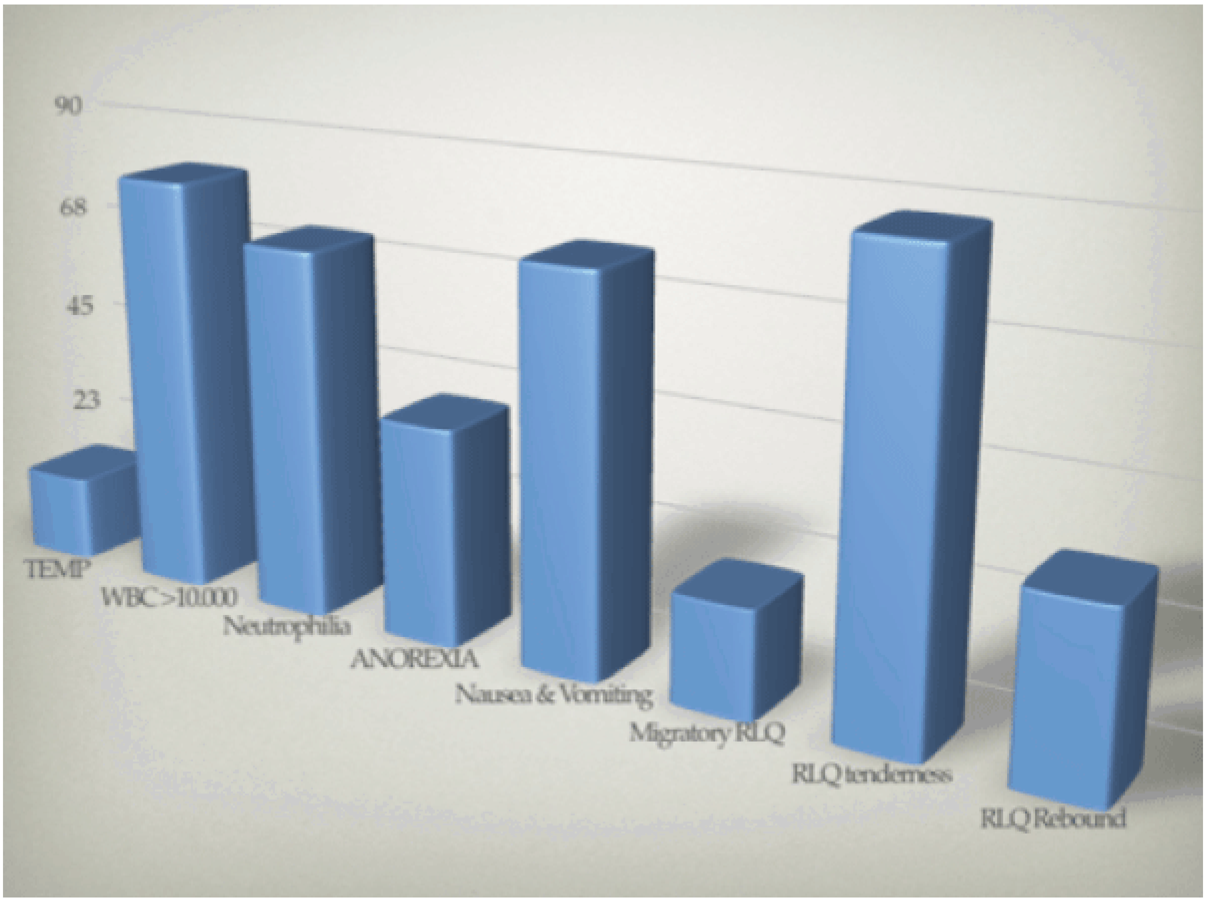

Figure 1: Alvarado score components.

Our exposure (independent) variable was Alvarado score. This score is used as a predictor of acute appendicitis and is made up of eight parameters each of which is assigned numeric values: temperature, right lower quadrant tenderness, rebound tenderness, migratory right lower quadrant pain, anorexia, nausea/vomiting, leukocytosis, left shift (neutrophilia), (Figure 1). Each parameter is assigned a score of 1 if present and 0 if absent, except leukocytosis and right lower quadrant tenderness which receive a score of 2 when present (Figure 1). For each patient we computed the total Alvarado score at the time of arrival in the ED.

The Alvarado score was subdivided into two categories of<7 and ≥ 7. This was based on earlier studies that had used categorized Alvarado score as a probable indicator of appendicitis [8-10]. Our outcome variable was CT scan order.

Data analysis

Demographic and baseline variables were presented as means and standard deviation for continuous variables and percentages for categorical variables. Differences in Alvarado score across strata of categorical baseline variables (gender, race) were analyzed using Pearson Chi square test. For continuous variables (age and BMI) p-values were determined using analysis of variance. We assessed difference in CT scan order between Alvarado groups ≥ 7 and Alvarado<7. Multivariate logistic regression analysis was used to identify any significant association between CT scan order and Alvarado score after adjusting for age and BMI for each strata of gender (Tables 1 and 2). Next we included gender in our analysis to see if there was any difference in our results. Statistical analysis was done using STATA 11.0 statistical software (STATA Corp, College Station, TX, USA). All statistical test were 2sided with a significance level of α=0.05.

	Complications	No Complications	
Alvarado Score	Frequency (%)	Frequency (%)	Total
A ≥ 7	10 (71.4)	79 (49.1)	89
A< 7	4 (28.6)	82 (50.9)	86
Total	14	161	175

Table 1: Alvarado Score and Complications.

CT scan order	OR (95% CI)	p-value
Male		
A<7	1.0 (referent)	
A ≥ 7	0.68 (1.42-2.15)	0.02
Female		
A<7	1.0 (referent)	
A ≥ 7	1.34 (0.62-1.88)	0.45

Table 2: Logistic regression, adjusted odds ratio of CT scan order (Adjusted for age and BMI).

Results

Demographics

There were 175 patients who met the inclusion criteria for the study. Mean age was 12 years (SD: 3.8) with a range of 2-18years; 64.6% were male. The mean BMI was 22.1 kg/m2 (SD: 5.16). Among our study population, 133 (76%) were Hispanic, 26 (14.9%) were Black/African American, 4 (2.3%) were white, 1 (0.6%) was Asian, 1 (0.6%) other and 10 patients (5.7%) had missing data on ethnicity. The general patient characteristics are shown in Table 2.

There were no statistically significant differences in baseline characteristics between patients with Alvarado ≥ 7 and those with Alvarado<7.

Clinical outcomes

Patients with Alvarado ≥ 7 made up 50.9% of our study population. Abdominal CT scan was ordered in 63.4% of the patients; 44.8% with Alvarado ≥ 7. There was no significant difference in proportion with CT scan order between those who had Alvarado score ≥ 7 and those with Alvarado score<7 (p-value 0.19) after adjusting for age, gender and BMI (Table 3).

Males with Alvarado ≥ 7 were less likely to get CT scan ordered compared to those with Alvarado<7, OR: 0.68 (95% CI: 1.4-2.1). Among females however there was no difference in CT scan order between the Alvarado groups, OR: 1.34 (95% CI: 0.45-1.88). Patients who had complications from appendicitis were 14 (8%); of these, 71.4% had Alvarado of ≥ 7. Among the patients with Alvarado score ≥ 7 and complications, 50% of them had CT scan ordered. For patients with Alvarado<7 and complications, 75% had CT scans ordered (Table 1).

CT scan order	OR (95% CI)	p-value
A<7	1.0 (referent)	
A ≥ 7	0.94 (0.56-2.15)	0.19

Table 3: Logistic regression adjusted odds ratio for CT scan order (adjusted for age, BMI and gender).

Discussion

In our study population, there was no statistical significant difference in CT scan ordered between patients with Alvarado ≥ 7 and those with Alvarado<7 after adjusting for age, BMI and gender. Thus patients with Alvarado ≥ 7 which indicates an increased probability of acute appendicitis were as likely to get CT scan before surgery compared to those with Alvarado<7.

Computerized tomography techniques have been in use for more than 30 years. CT is almost uniformly available in all hospitals and emergency rooms in the United States. The use of CT imaging has increased dramatically in the past 10 years, nearly 70% [11]. In the United States, approximately 11% of CT scans are performed on children [12]. The major disadvantage of CT is ionizing radiation. The approximate dose for a child of a single CT of the abdomen and pelvis performed with appropriate, age adjusted CT parameters is 5 m Sv [6]. This is equivalent to having 250 X-rays. While high dose radiation exposure is well known to be associated with the development of malignancy, even low doses of radiation, in the ranges of 10-50 m Sv, incur an increased lifetime risk of malignancy [13,14]. In addition, CT scan is not 100% sensitive in diagnosing acute appendicitis [15]. There are a substantial number of patients in whom the findings on CT images are misleading or equivocal. In one study 30% of patients with equivocal findings on CT had acute appendicitis [16,17] Pediatric studies have shown that despite increase utilization CT negative appendectomy rate remained unchanged [18]. As clinical threshold levels for ordering CT become less defined, increasing numbers of children with other disorders mimicking appendicitis are being scanned [6].

Accurate diagnosis of acute appendicitis remains a challenge in emergency medicine especially in children who may not be able to articulate their symptoms well. However a detailed history and physical examination as well as early surgical consultation may reduce the need for any imaging diagnostic tests [19-20].

Conclusions

We found no significant difference between CT scan order and Alvarado score. There was no significant difference between Alvarado score and gender, race/ethnicity or BMI (Tables 2 and 3).

Despite the wealth of information regarding the role of clinical skills in reducing the need for imaging in diagnoses of acute appendicitis, our study showed no difference in CT order based on clinical presentation. Implementation of a selective protocol using clinical scoring can reduce the need for computed tomography, be cost effective and time efficient in the emergency department. A multicenter study looking at the practice across different emergency rooms and among different populations could be a topic for future research.

Limitations

1. The retrospective design did not allow for patient follow up.

2. The study was conducted at single community hospital.

3. The majority of our study population are Hispanic. It is of interest to see if a similar trend pertains in other geographic regions with a different mix of ethnicity.

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